



3D Imaging Benefits Wearable Technology

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Abstract

A new class of applications for unique, customized products is becoming possible with the advancement of 3D scanning technologies ability to acquire real-world shapes, advanced software to process and design from that data, and free-form additive manufacturing technologies that can produce unique objects in a variety of materials at a low per-unit cost.

Introduction

Recent advances in manufacturing technology, such as 3D printing and 3D weaving, are enabling new applications for products that are customized or created on-demand. These processes are not limited by geometric complexity, and can fabricate unique shapes at a relatively low cost. The major limitation then becomes the accuracy of the digital design, and the labor used to create it. 3D imaging technologies offer a solution for part of this issue. Wherever a product must interact with a complex natural form, digital reconstructions based on 3D scans can help guide the design process. While this general work-flow has been possible for some time, for example in the production of medical implants, the design of customized products from 3D scans has traditionally required expensive software and skilled labor.

While fully automated mass-customization of products based on scans has only seen rudimentary examples, enough advances have been made to open new applications beyond medical implants and aerospace. Those advances include: Low cost scanners and 3D imaging from photographs (photogrammetry), Expired patents for 3D printing and simplified construction of desktop fabrication machines, and development of advantage software for design and data processing, available at a low cost or even free.

This research considers applications like wearable computing (communication), health monitoring and therapy (orthotics and drug delivery) specialized occupational tools, sports, and fashion.

Photogrammetry Capture of Sketched Designs

This first example from 2011 examined the feasibility of using an intuitive, user-friendly method to establish the initial design intent. Rather than capturing the form and designing digitally, the initial form was sketched directly on the skin. Color photogrammetry recorded those shapes, which used as input for the design.

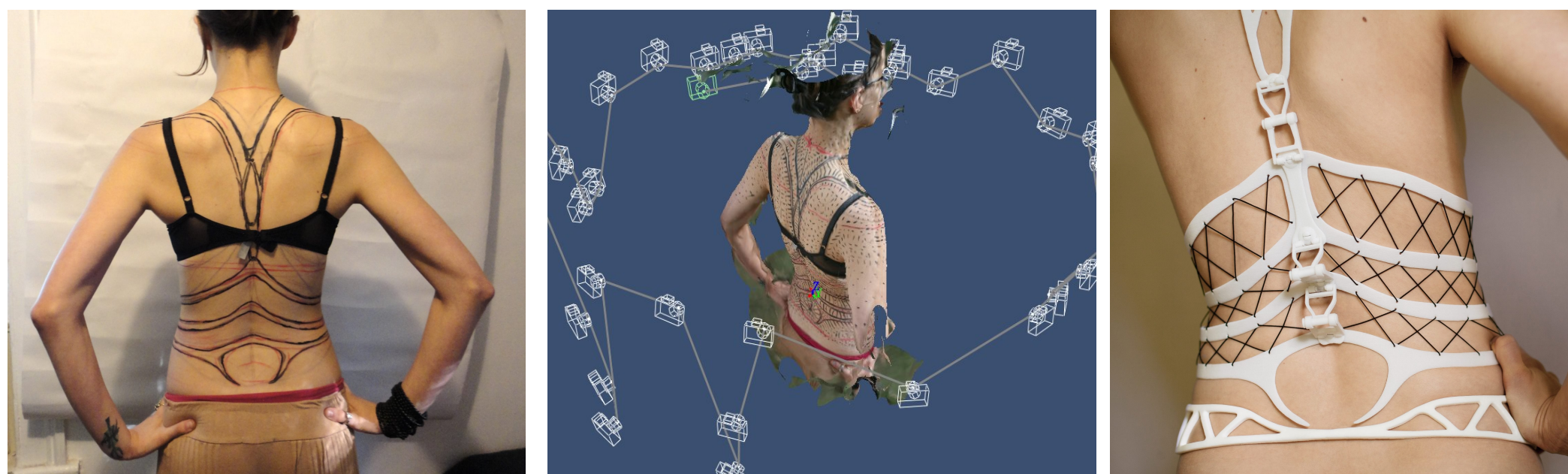


Figure 1-3: 3D Geometry Captured from Sketch and Reproduced with SLS Nylon.

The Sketched shapes were manually traced as 3D splines. A volumetric sculpting program was used to extrude the geometry from the surface, and solid modeling CAD software was used to design functional components like hinges, fasteners, and sliding joints.

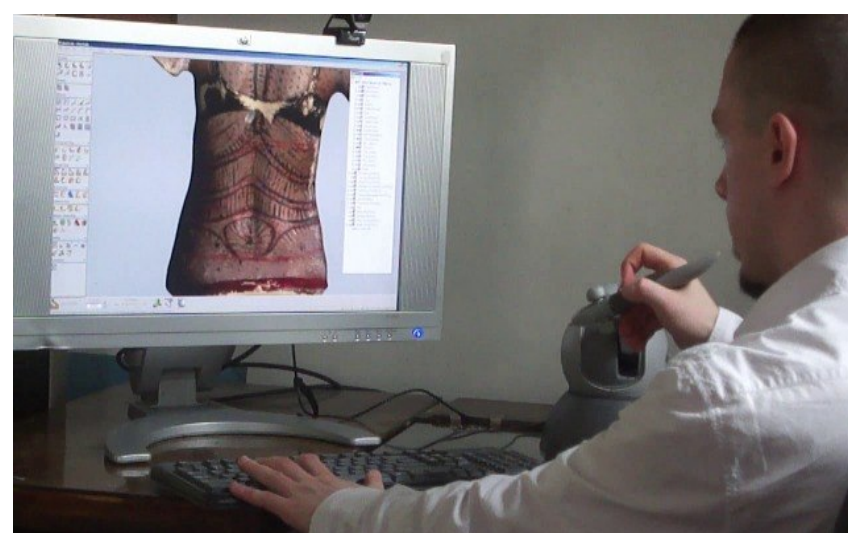


Figure 4. Editing the mesh with a haptic sculpting tool

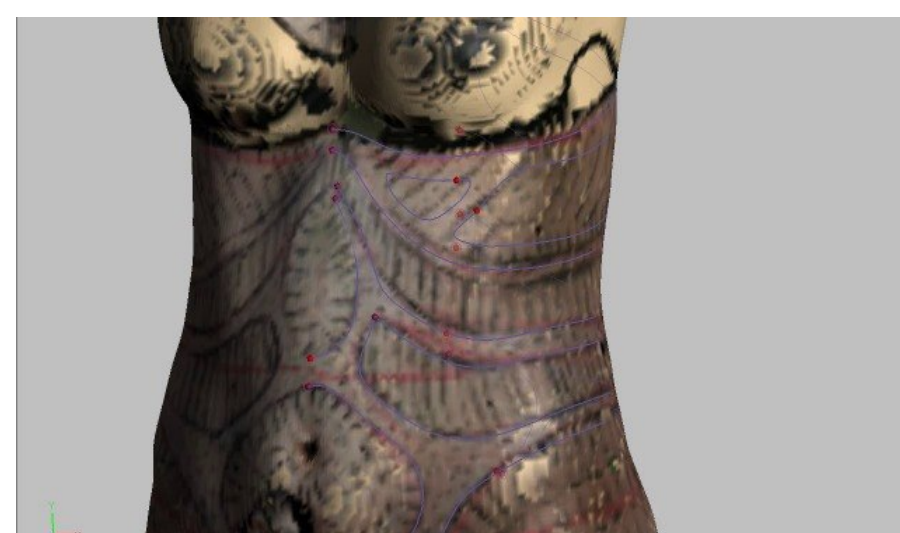


Figure 5: Tracing splines On the sketched design

The process requirements suggest that the development of an algorithm that can generate a curve in 3D from the colors of scanned geometry would be useful for capturing the design intent of the sketch with less labor. Issues with scan resolution and line clarity create challenges to achieving this goal. Placement and orientation of the functional CAD components is also currently manual. Varying angles and surface geometry means that components must often be varied to fit the body context.

This example (a 3D-printed corset) is primarily an aesthetic design that explores custom fitting and basic wearability using this process. The intuitive approach of using simple cameras for 3D capture and intuitive sketching as an input to modeling creates the possibility that consumers with no training might someday be able to specify the form and placement of complex generative designs. A further development using symbols to specify functionality can guide the placement of functional components by automated means.

Advanced Mechanics and 3D “Body Profiles”

Adaptation of design between individuals can be partly automated by aligning body geometries and projecting curves perpendicular to the surface, but changes between individuals introduce inaccuracies. In an effort to explore the limitations of the approach, a more complicated example was attempted in an application that had greater functional/mechanical requirements, using a range of individuals.

Several members of the University of Bridgeport Gymnastics team were digitized with a high-resolution white-light scanning system, and custom-fit body-conforming structures were built for each individual, projecting many of the same curves onto each surface.

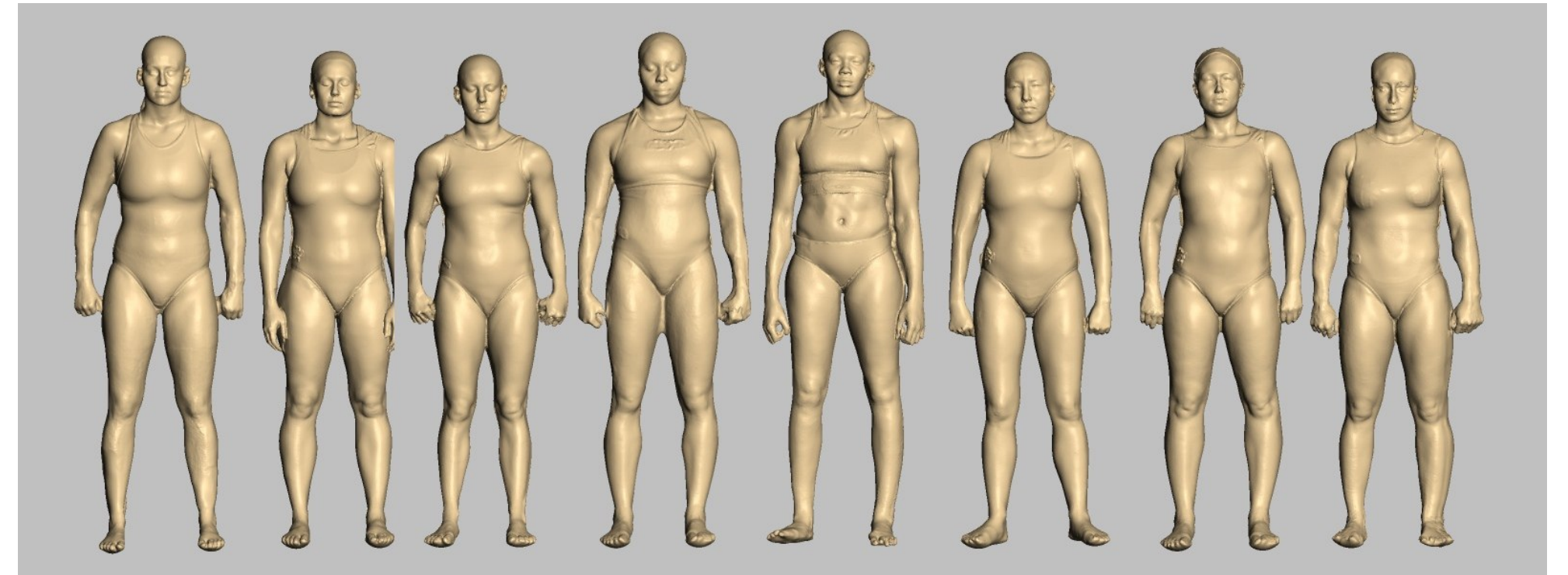


Figure 6: High resolution body scans as input for dynamic mechanical structures

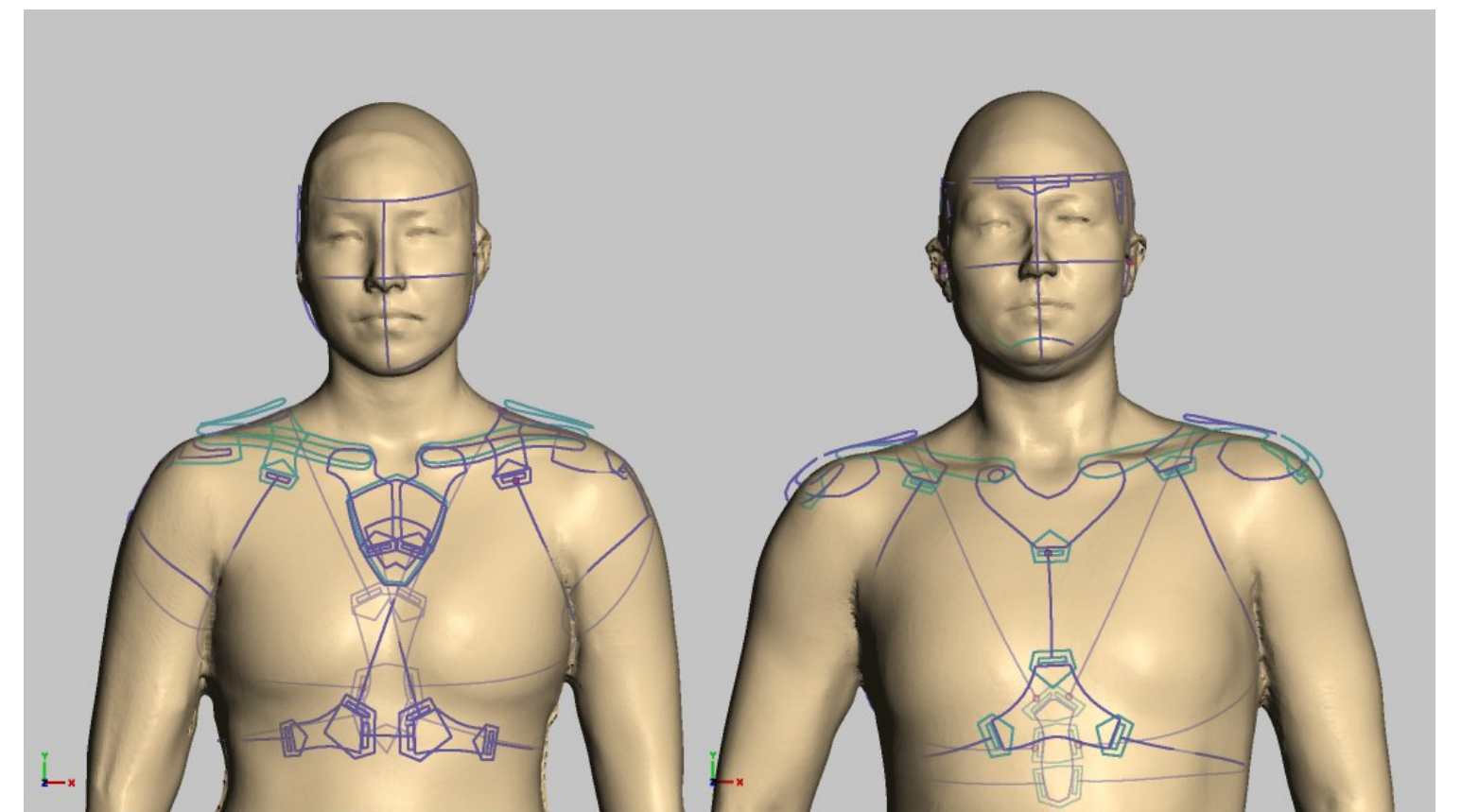


Figure 7: Surface curves projected between scans

Figures 6,7 Show an accelerated design process that shares features, measurements, and inserted CAD components (hinges, ball-joints). Five custom fits designs were created and manufactured using 3D printing in less than two weeks.



Figures 8, 9: Coated 3D Printed components, ball joint mechanism

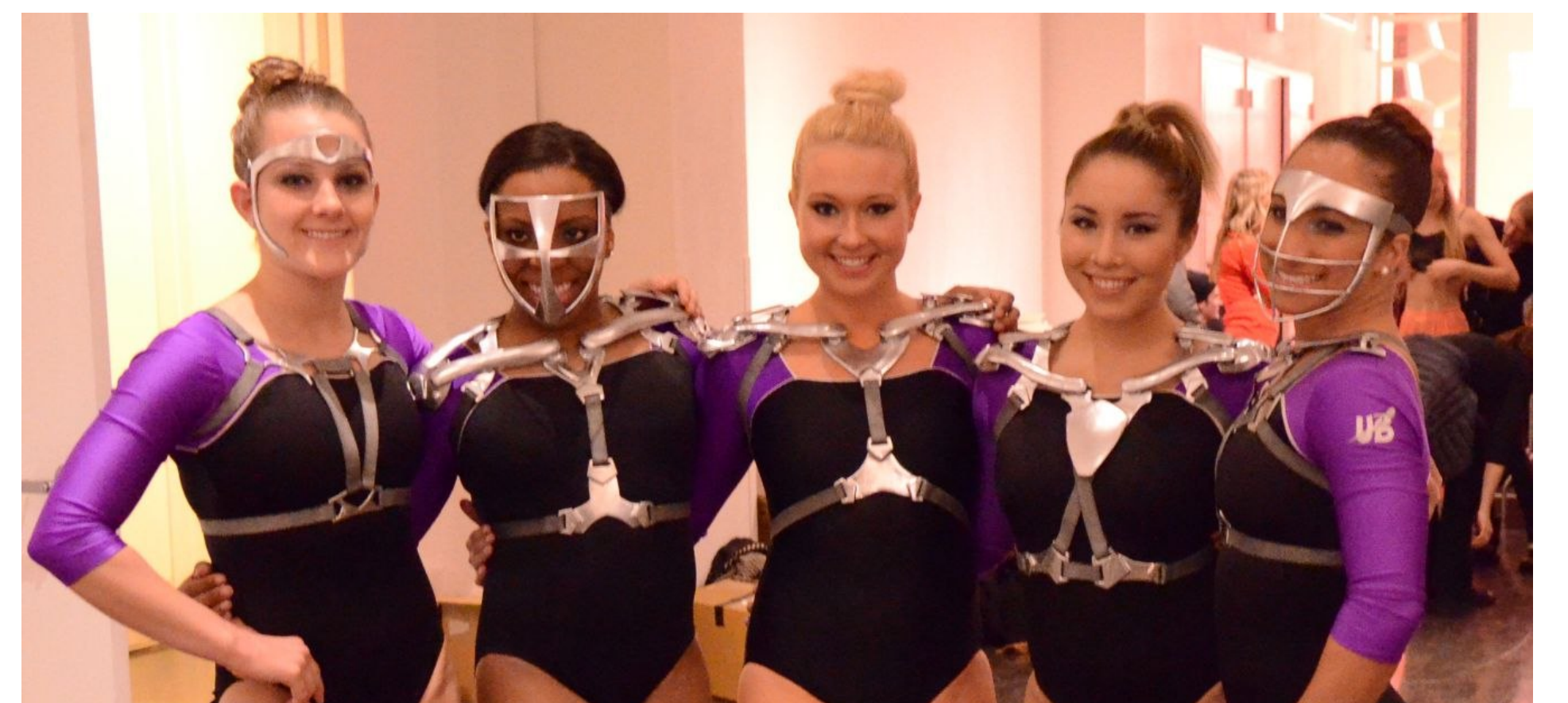


Figure 10: Personalized mechanical surface structures fabricated with 3D printing

Customized designs that are fit using 3D scans and printed with additive manufacturing can be housing for electronics, functional structures, and with advances in materials, they can become wearable garments. An essential step in making this happen will be the rapid creation and adaptation of designs. New methods that use statistical models of the human body built from thousands of scans can be used to accurately transform designs, and similar algorithms are already used in the entertainment industry to transfer actors performances to animated characters.

Adaptable, personalized products can integrate the functions of many technologies into a seamless, unobtrusive wearable system. The generative structures can be virtually unlimited in complexity, vary in function over different parts of the body, and can be generated on-demand or possibly even transform themselves based on the needs of the wearer. Other future developments include wireless power and communication systems, distributed computing, environmental management (heating, cooling, and humidity control), and many other as-yet undeveloped uses.